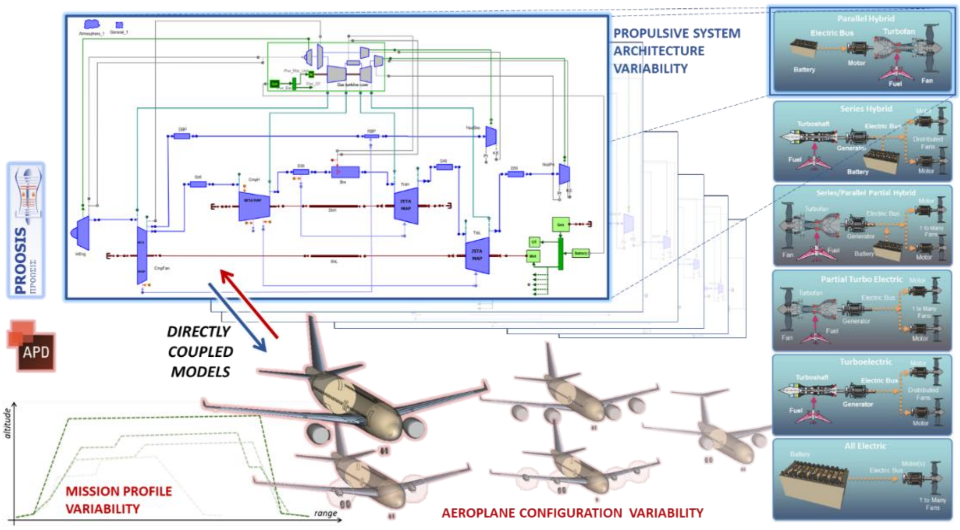
Hybrid-Electric Propulsive Systems Model Development

Project Description

Hybrid-electric propulsive systems are of constant interest to the aeronautical industry for their potential to provide the necessary function at lower in-flight harmful emissions. The fulfilment of the potential relies not only on improvement of specific power/energy of the electrical sources and components, but also finding better ways to exploit synergistic effects of such systems with the rest of the aircraft as well as the operating profile of the vehicle. Therefore, a capability to ***robustly model such propulsive systems at a good level of detail***, and integrate them into full aeroplane mission sizing modelling schemes is indispensable for decision making in conceptual/preliminary design of new hybrid-electric vehicles.

To that end, developments are ongoing at ISAE-SUPAERO's Department of Aerodynamics, Energetics and Propulsion (DAEP) to develop hybrid-electric propulsive system preliminary sizing models using industry-standard software ***PROOSIS™***[1]. The work attempts to create a library of canonical[2] ***hybrid-electric propulsive system architectures*** (series-hybrid, parallel-hybrid, turboelectric…) which can be sized and design for any configuration and operating point/profile of interest. While the groundwork has been laid and basic descriptions of the architectures are developed and operational, a great deal of detailed development is still necessary. The goal of this internship is to pursue the further development, where the following factors intersect:

- Current state of the development at the time of the beginning of the internship (spring 2024),
- Objectives for further development of the framework at the DAEP,
- Research interests and affinities of the candidate.



Summary illustration of the extend of the aeroplane design space to be made accessible with fully developed PROOSIS and Pacelab APD models.

It is worthwhile to underline that the development is pursued in conjunction with other developments that aim to couple[3] PROOSIS propulsive system models to whole aeroplane mission sizing models in

[1] https://www.ecosimpro.com/products/proosis/

[2] Cf. [Commercial Aircraft Propulsion and Energy Systems Research: Reducing Global Carbon Emissions](#) (NASEM 2016), chapter 4.

[3] Joksimović et al. 2023: 'Direct Software Coupling for Aeroplane Sizing and Integrated Aeroplane-Engine Mission Performance Simulations' (https://doi.org/10.2514/6.2023-1164)

software Pacelab APD™[4]. (see the figure above) While that work will not be pursued in this summer internship project, the developments will need to fit the framework; the candidate will thus have ample opportunities to learn and discover more on the system integration aspect of the propulsive system preliminary sizing and design.

Main Objectives and Potential Pathways

Potential research and development pathways are (in no order of preference):

- Developing robust cases for ***multi-point/profile-based sizing*** of the different systems architectures (for the moment we size most of them only at single operating point, which is not good enough to access the full performance of such systems; for info – we have developed Matlab codes that allow us to multi-point size different gas-turbine propulsive system models, which can be made available to the candidate for the current application cases);
- Pursuing ***trade studies*** across the system design space, exploring the influence of e.g. size and number of propulsors on the overall system performance and energy efficiency (for example for the moment we can vary the number of propulsors in an architecture, but we cannot yet make decisions meaningfully based on the required performance and possible constraints on the system such as propulsor size, power density of the electrical machines, etc.);
- Integrating robust ***whole-system figures of merit*** and testing their applicability in different resolution schemes (for example, gas-turbine engine models are easily steered with the net thrust setting, but a distributed hybrid-electric system needs to be complemented with other variables such as hybridisation ratios, which might differ depending on the architecture we choose to model).

Candidate Requirements

Compulsory: thermodynamics/propulsion; basic knowledge of electrical systems; multidisciplinary analysis; autonomy; research-oriented candidate profile.

Optional: optimisation; Matlab.

Number of candidates: 1

Language: English and/or French (not compulsory)

Additional Information

- The summer internship takes place between May and August 2024, preferably over 3 whole months; it is not paid;
- Possibility of conference/journal publication if the performed work and obtained results are satisfactory.

Contact

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[4] https://pace.txtgroup.com/products/preliminary-design/pacelab-apd/